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UNIT TRAINING AND EVALUATION SYSTEMS TECHNICAL AREA

U. S. Army

Research Institute for the Behavioral and Social Sciences

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EVALUATION OF TWO TANK GUNNERY TRAINERS

INTRODUCTION

The effort addressed in this report is part of a larger one with the objective of developing a model which can be used to predict and to evaluate the effectiveness of training devices. The modeling is particularly aimed at describing how device design, device use, training strategy, and individual ability interact to influence device effectiveness. Standards of effectiveness include both acquisition and transfer of military skills with emphasis placed upon transfer from training to operational settings. The model treats training device effectiveness as a function of: (1) the transfer potential of the device; (2) the learning deficit of the trainees; and (3) the extent to which appropriate training techniques are utilized in the device. Details of the development and rationale of the model are discussed in earlier reports in this series (Wheaton, Rose, Fingerman, Korotkin, and Holding, 1974, 1976; Wheaton, Fingerman, Rose, and Leonard, 1976).

In support of this modeling effort, a series of field studies was conceived which would provide empirical data against which predictions from the model could be evaluated. Based on a review of current Army training devices, Armor School curricula, and interviews with cognizant Army personnel, a group of training devices was selected for intensive examination. It was desired that the selected devices all be applicable to a common training objective in order to facilitate comparisons. Further constraints included local availability, feasibility of use, and ease of instructor and trainee orientation and operation.

To initiate the series of field studies the decision was made to study devices potentially or actually used to train Burst-On-Target (BOT) principles within the context of the Armor Branch of Combat Arms. The most recent report in the current series (Wheaton, Rose, Fingerman, Leonard, and Boycan, 1976) described the results of the BOT field experiment. It evaluated the effectiveness of three training devices for preparing Advanced Individual Training (AIT) trainees to apply BOT techniques with the 3A102B laser device mounted in the M60A1 tank.

The present report documents the procedures and results of a second field study in which AIT personnel were trained to three different levels of proficiency in tracking on two training devices and transferred to a live-fire tracking task using the main gun of the M60A1 tank. The devices selected for evaluation in this experiment were: (1) the M73 coaxial machine gun firing in the single shot mode, mounted in the M60A1 tank; and (2) the 3A102B laser device mounted in the M60A1 tank. An interesting feature of these devices is the degree and type of simulation provided. The M73 involves actual live firing of a machine gun at a moving target located downrange. This requires procedures similar to actual firing of the main gun. For example, the gun makes a noise when fired, safety precautions take on a more realistic appearance, and an actual hole is made in the target when a hit is

scored. The 3A102B laser device simulates main-gun firing with a laser mounted in the M73 machine gun bracket on the tank. No noise is involved and the only safety precatuions involve the avoidance of laser injury to the eyes of personnel outside the tank. Also, hit/miss feedback is provided only by a brief pulse of light on the target.

The general plan was to train three groups on each device to proficiency levels of 30%, 50%, and 70% accuracy respectively. These groups then transferred to the main gun on the M60A1 tank where each trainee fired twelve rounds. An additional group served as a control group and did not practice on any of the devices prior to transfer to the main gun. Transfer effectiveness was conceptualized primarily as the accuracy with which trainees could hit a moving target with the main gun. However, a variety of other measures of trainee performance was also examined in order to evaluate training effectiveness.[1]

APPROACH

OVERVIEW

The purpose of this experiment was to evaluate the training effectiveness of two tank gunnery training systems. An additional goal was to determine the level of proficiency which students should reach on the device in order to maximize initial (12-shot) transfer on the main gun. The basic approach was to select students who, while having had classroom sessions on main-gun firing and adjustment-of-fire procedures, had not had any practice on the actual tasks. Individual students within several experimental groups then practiced tracking and firing until a predetermined proficiency level was achieved. Following training, each experimental student tracked and fired for a total of 12 main-gun rounds. An additional control group also tracked and fired 12 rounds; however, they did not have the benefit of prior training.

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[1] LTC Willis G. Pratt, Chief, U. S. Army Human Research Unit, Fort Knox, Kentucky, gave valuable assistance as research coordinator. COL Roderick D. Renick, Commander, First Training Brigade, Fort Knox, and LTC Bruce McConnell of the First Trainig Brigade critiqued the study plan and supported the experiment with their instructor and trainee personnel. CPT Ernest Wagner, First Training Brigade, served as Project Officer, and CPT Raymond J. Quilling, Company Commander, Delta 3-1, contributed the hypothesis about target speed and lead/lag misses which has been incorporated in this report. Finally, S/Sgt. Elder R. William, NCOIC Tank Section, Dept. Range Division, Fort Knox, was instrumental in keeping the coax and main-gun ranges operating under the most trying of circumstances.

TRAINEES AND INSTRUCTORS

One hundred fifty-four 11E10 trainees from D Company, 3rd Battalion, 1st Training Brigade at Fort Knox served as subjects for this study. These trainees were assigned to seven groups (2 devices x 3 proficiency levels + 1 control) of 22 subjects each.[2] Groups were matched as closely as possible along dimensions of potential influence on training and transfer. These dimensions were: (1) Army status (regular Army or other); (2) prior service; and (3) General Technical scores on the Army Classification Test.

A total of 12 11E qualified tank commanders served as instructors. Five were obtained from the 2nd Battalion and seven from the 3rd Battalion, Fort Knox. The 2nd Battalion tank commanders conducted the M73 coax portion of the training. The 3rd Battalion tank commanders conducted the laser training and the live-fire test. All instructors were briefed on experimental procedures, and time was set aside for practice with the devices prior to the conduct of the experiment. No directions were given to instructors as to specific teaching techniques for tracking and firing. Additional personnel support included spotters (to assist the instructors in determining hits or misses during training and transfer); seven spotters were provided by the 1st Battalion and five were provided by the 5th Cavalry.

DESCRIPTIONS OF TRAINING SITUATIONS

M60A1/3A102B Laser. This device is a low-power gas laser mounted in the M73 machine gun bracket in the M60A1 tank. Once boresighted and zeroed, the gunner and tank commander utilize the same optics normally used with the main gun. The primary function of this device is to simulate main-gun rounds. When the trigger is pressed, thereby activating the laser, a low-power red pulse (duration of 1/10 of a second) is emitted. The laser beam does not simulate a tracer round that could be sighted to the target; rather, upon striking a target, the red-light return represents the shell burst. The device also simulates flight time of a real shell fired at a moving target. This is accomplished via a "built-in" 5-mil displacement from the zero point. Thus, when a target is moving from left to right and the gunner's crosshairs are sighted on the center of the target, the burst will be displaced approximately 5 mils to the left (behind the target). Unfortunately, this built-in lead is in the wrong direction if the target is moving from right to left; in effect, the gunner would have to aim

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[2] Originally, 160 trainees were assigned to the experiment, with 28 subjects assigned to the control group. However, six of these control subjects did not fire the entire 12 rounds and were eliminated from the analyses.

behind the target in order to have the burst land on it. To avoid this, trainees fired only when the target was moving from left to right, and merely tracked it when it moved right to left.

The physical setup of the laser training is shown in Figure 1. Five tanks were employed during training. Each tank had its own target board. The targets were 3.5" squares outlined in black tape mounted on the high-reflectance target boards. The targets used were smaller than standard size in order to compensate for the smaller equipment error in the "M-53." Straight-line distance from the tanks to the targets was approximately 60 meters. The target boards were mounted on two separate tracks (for convenience); each track had a half-cycle period of approximately 25 seconds. Thus, the targets moved from left to right for 25 seconds, stopped for a short time (5 seconds), reversed, and moved from right to left for 25 seconds.

The training procedure was as follows. For each trial, the tank commander issued a three-element fire command (e.g., "Gunner, HEAT, tank"); the student announced "Identified" and took initial aim; the loader said "Up"; the tank commander ordered "Fire"; the student announced "On the way," paused, and fired. For the laser training, students fired two rounds in each left-to-right target pass. Due to the inappropriate lead of the laser, students did not fire when the target moved from right to left; rather, they simply continued tracking the target. After each shot, the student was informed whether or not his round had hit the target and this information was recorded on a score sheet (Appendix A). Training proceeded in this fashion until the student reached his assigned proficiency level. If he had not reached the criterion by the time he had fired 40 rounds, the student ceased fire and rested. He then resumed firing until he reached criterion.

M60A1/M73 Coaxial Machine Gun (Single Shot Mode). This device is an operational M73 machine gun equipped with an interrupter mechanism. This feature restricts fire from the machine gun to one shot at a time. Aside from this restriction, the machine gun operates normally.

The physical layout of the coax training is shown in Figure 2. Five tanks were utilized during training, each with its own set of targets. The targets were the standard M73 Table III targets (8" x 6" tank silhouettes) used in regular training. Periodically, "stick-ons" were placed over holes in the targets to improve spotting accuracy. In order to facilitate spotting of rounds and to eliminate large angular displacements of each target from its tank, three firing fans were used, as illustrated in Figure 2. Firing for each tank was limited to the space between the appropriate barber poles. Straight-line distance between each tank and its target was approximately 60 meters.

Training procedures were practically identical to those used in the laser training with one exception. Students fired two rounds when the target moved left-to-right and two rounds when it moved right-to-left. After firing, students continued to track the target. Again, training terminated when a student reached his assigned proficiency criterion.

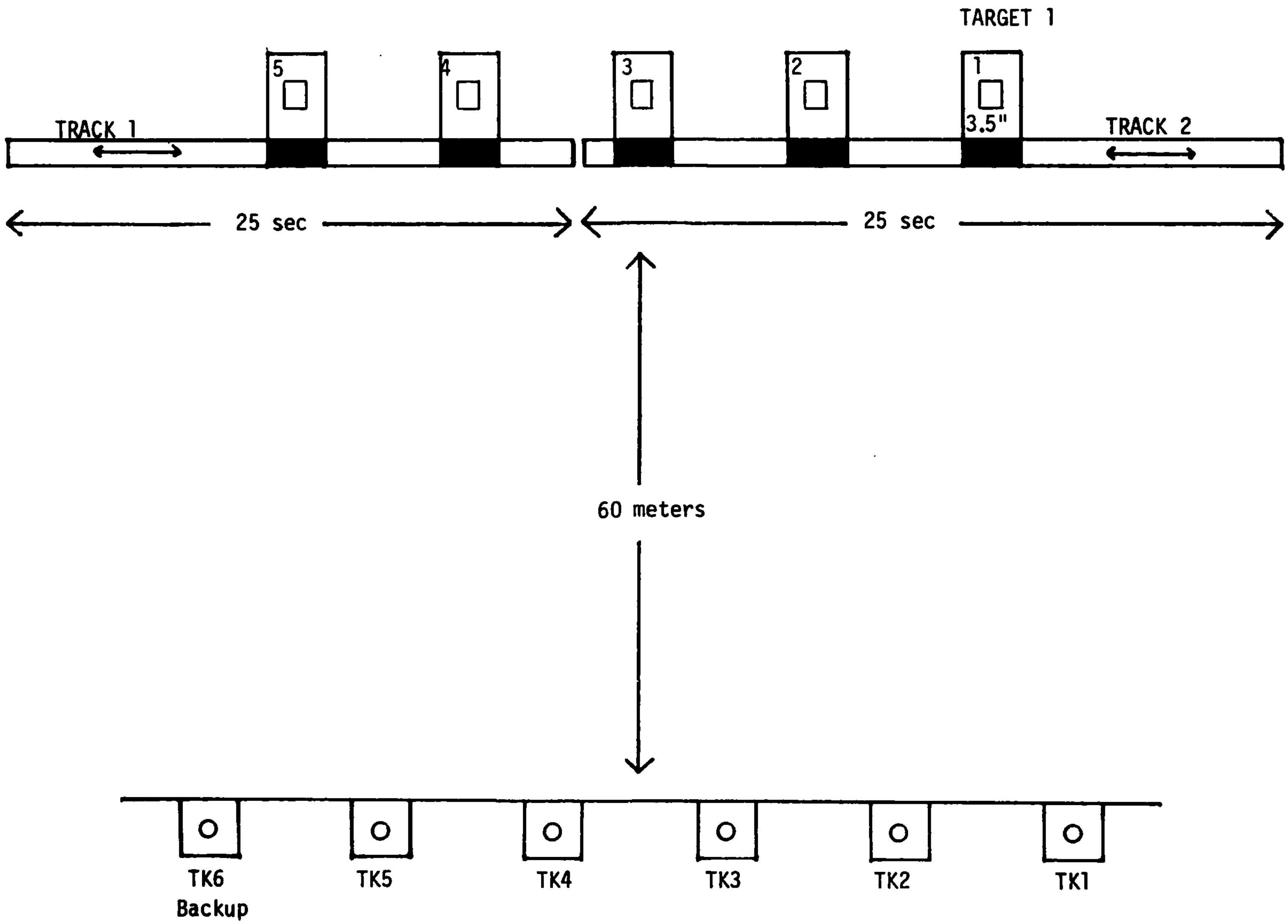

Figure 1. Laser range setup (Quinn).

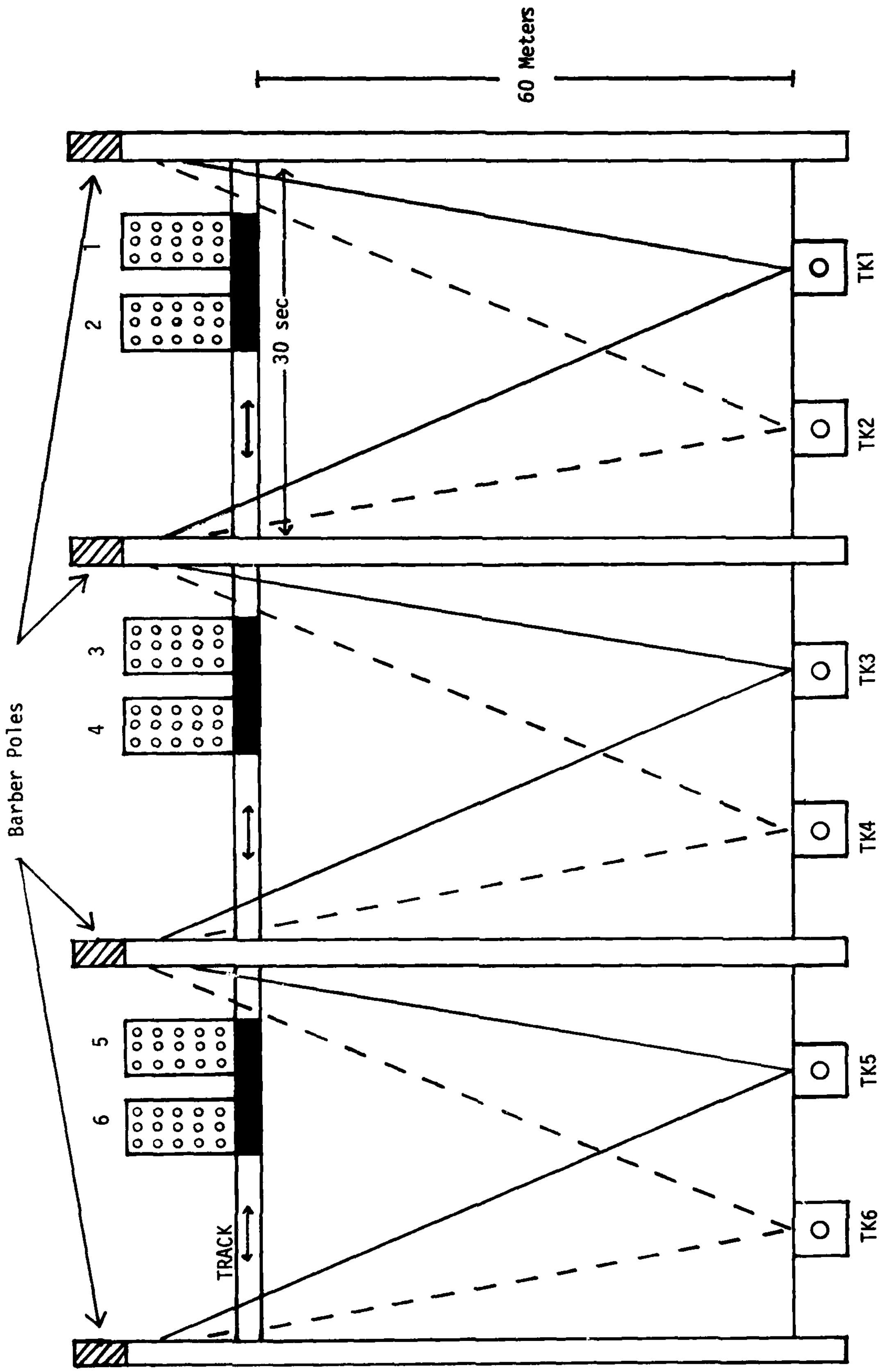

Figure 2. Coaxial machine gun range setup (Finney).

Proficiency Criteria During Training. Three levels of proficiency were employed as training performance criteria: 30%, 50%, and 70%. Training ceased for a 30% proficiency trainee when he hit six targets out of any 20 consecutive trials. If, for example, he obtained hits on his first six shots, training ceased. While labelling this student as only 30% proficient was highly arbitrary, such designations were necessary in order to enable comparison across proficiency groups. Comparable hit rates were 10 hits out of any run of 20 trials for the 50% group, and 14 hits out of any run of 20 for the 70% group.

TRANSFER TASK: LIVE-FIRE EXERCISE

The physical layout of the live-fire portion of the experiment is shown in Figure 3. Seven tanks were utilized, with two backup tanks. (Due to various problems, all nine tanks were eventually used during this exercise.) Ammunition was standard 105 mm HEAT TPT. The targets were two 16′ x 10′ plywood silhouettes mounted side-by-side on a motor-driven cart. During the course of the experiment, the target silhouettes were placed several times to enhance spotting accuracy. The straight-line distance between the targets and the tanks was approximately 700 meters (near pass) and 750 meters (far pass).

The target cart moved along an oval track at a constant speed. The targets moved left to right for approximately 2 minutes and 30 seconds, disappeared for approximately 30 seconds, and reappeared moving right to left for 2 minutes and 30 seconds.

The procedure for each target engagement was as follows. When the target passed a barber pole and entered the fire fan, the tank commander issued a three-element fire command. The gunner announced "Identified," heard "Up" from the loader, "Fire" from the tank commander, announced "On the way," paused, and fired. Students fired two or three rounds per pass (as determined by the tank commander′s judgment) for a total of 12 rounds, six in each target movement direction. For the second and third shots on a given pass, the tank commander issued the fire command immediately after the first shot was fired. In order to minimize fatigue, a given student fired only half of his twelve rounds at a sitting. After six rounds, he got out of the tank and was replaced by another student. Four students were assigned to a given tank; these students rotated through the loader and gunner positions, six rounds per position, until all four had fired twelve rounds.

Due to the shortness of the range, obscuration caused by muzzle blast, and concussion, tank commanders could not accurately spot rounds; therefore, spotters were assigned to each tank and located at the positions shown in Figure 3. They were provided with binoculars or BC scopes to further improve spotting accuracy. Each spotter was in voice contact with the tank commander; the spotter provided hit-miss feedback after each target pass. He also recorded the location of the round in relation to the target on a specially prepared scoring sheet (Appendix B).

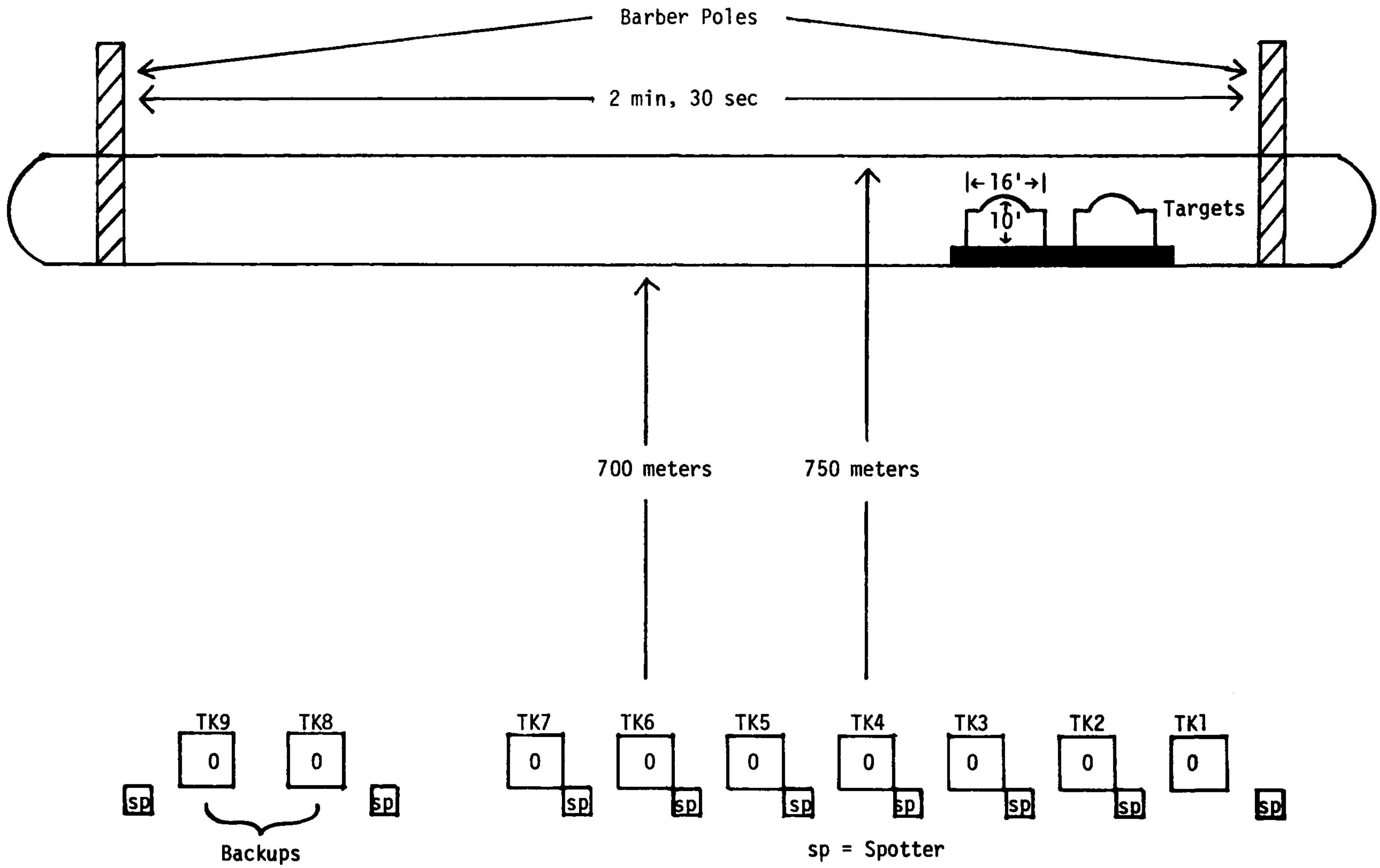

Figure 3. Live-fire setup (Boydston).

CONTROL AND COUNTERBALANCING PROCEDURES

In order to insure the validity of the obtained results, various counterbalancing procedures and experimental design constraints were built into the training and transfer portions of the experiment. With respect to the students involved, all participated in the experiment at the start of the seventh week ("gun week") of training in the 11E10 program. Thus, all subjects had identical pre-experimental treatment. No student had received any practice involving either of the devices. Further control was exercised by insuring that the sequence of events in the different training situations was as similar as possible. All instructors were given a pre-experimental briefing at the same time, the instructors were provided with practice on the experimental procedure, and research personnel carefully monitored the actual conduct of the training and transfer portions of the study.

Counterbalancing procedures were employed to reduce or eliminate differential effects due to a number of factors. The training portion of the study was administered over two days; likewise, the transfer portion of the study took place on two different days. Day-to-day variations in weather and, consequently, in target visibility were taken into consideration by training an equal number of students from each of the six experimental groups on each of the two training days. Within-day fluctuations in weather conditions were dealt with by insuring that at any moment in time, on either of the two training or two transfer days, an equal number of students from each of the groups was performing the task. Potential differences among the instructors working with a given device were effectively controlled for over the course of training by having each instructor train an equal number of students from each of the three proficiency-level groups assigned to his device. Since instructors did not change tanks (i.e., devices) during training, this procedure also reduced the potential confounding of lasers and training conditions. Similarly, during the transfer portion of the experiment, an equal number of students from each of the seven groups performed the live-fire test on each tank, thus reducing possible bias due to different instructors or tanks. All students trained on Monday transferred to the live-fire exercise on Wednesday and all of the Tuesday trainees fired on Thursday. Thus, the training-transfer interval was approximately 1 1/2 days for all trainees. Since an equal number of students from each group was trained on Monday and Tuesday, this procedure reduced possible differential training-transfer interval effects.

One of the more difficult factors to control for was the potentially different amounts of practice required to reach the same criterion level on the two different devices because of differences in device accuracy. For example, the coax is an area-fire weapon and has a built-in dispersion, while the laser has a much reduced shot scatter. Thus, given standard targets, the laser should inherently be a much easier device with which to hit a moving target. Nevertheless, to insure the validity of the present experiment one had to avoid the situation wherein an equivalent proficiency level for the two devices resulted in vastly different amounts of practice. For example, it was hoped

that the 50% proficiency groups on each device would take the same number of trials to reach criterion performance.

To deal with these issues a small pilot study was conducted in an attempt to identify conditions that were approximately equivalent, in terms of difficulty, for the two devices. It was determined that the normal targets used in laser training could be reduced in size to 3.5" squares, thereby increasing the difficulty of that task and equating it to the coax task.

RESULTS

In presenting the results of the tracking field study, emphasis has been placed on those findings which permit an evaluation of the effectiveness of three amounts of training on the 3A102B and M73 devices. Accordingly, the findings have been arranged under two general headings. First, data are presented which describe how trainees in the various device groups acquired skill in shooting at a moving target during training. Of primary interest is the difficulty which the various training groups encountered, especially when compared across the two training devices. Data under the second heading address the question of how successful trainees in the various groups were in transferring their tracking skills to the test situation--in this case to live-firing of the M60A1 main gun.

ACQUISITION OF TRACKING SKILL

Groups were compared in terms of the number of trials required to reach the specified criterion levels (i.e., 30%, 50%, or 70%). Figure 4 shows the mean number of shots required as a function of criterion level and type of device. Differences in number of shots to reach criterion were expected, of course, as a result of setting different criterion levels in the first place (i.e., 6/20, 10/20, and 14/20). Accordingly, Figure 4 also presents trials-to-criterion data which have been adjusted by removing the minimum number of trials which were demanded by each criterion level.

An analysis of variance conducted on the adjusted data revealed a significant main effect of proficiency level on the number of shots required in excess of the minimum [$\underline{F}$ (1,126) = 11.25, $p < .001$]. However, more detailed analysis indicated that the effect was primarily due to the significantly greater number of shots required by the 70% group relative to the 50% or 30% groups (mean difference = 8.4 and 11.0, respectively; $\underline{F}$ (1,126) = 5.98, $p < .025$); $\underline{F}$ (1,126) = 10.26, $p < .005$. No significant differences were obtained between devices in either the raw or adjusted trials-to-criterion data. Therefore, the two training devices were of comparable difficulty. On both of them, achieving the 70% level of proficiency was significantly more difficult than reaching the lower proficiency levels.

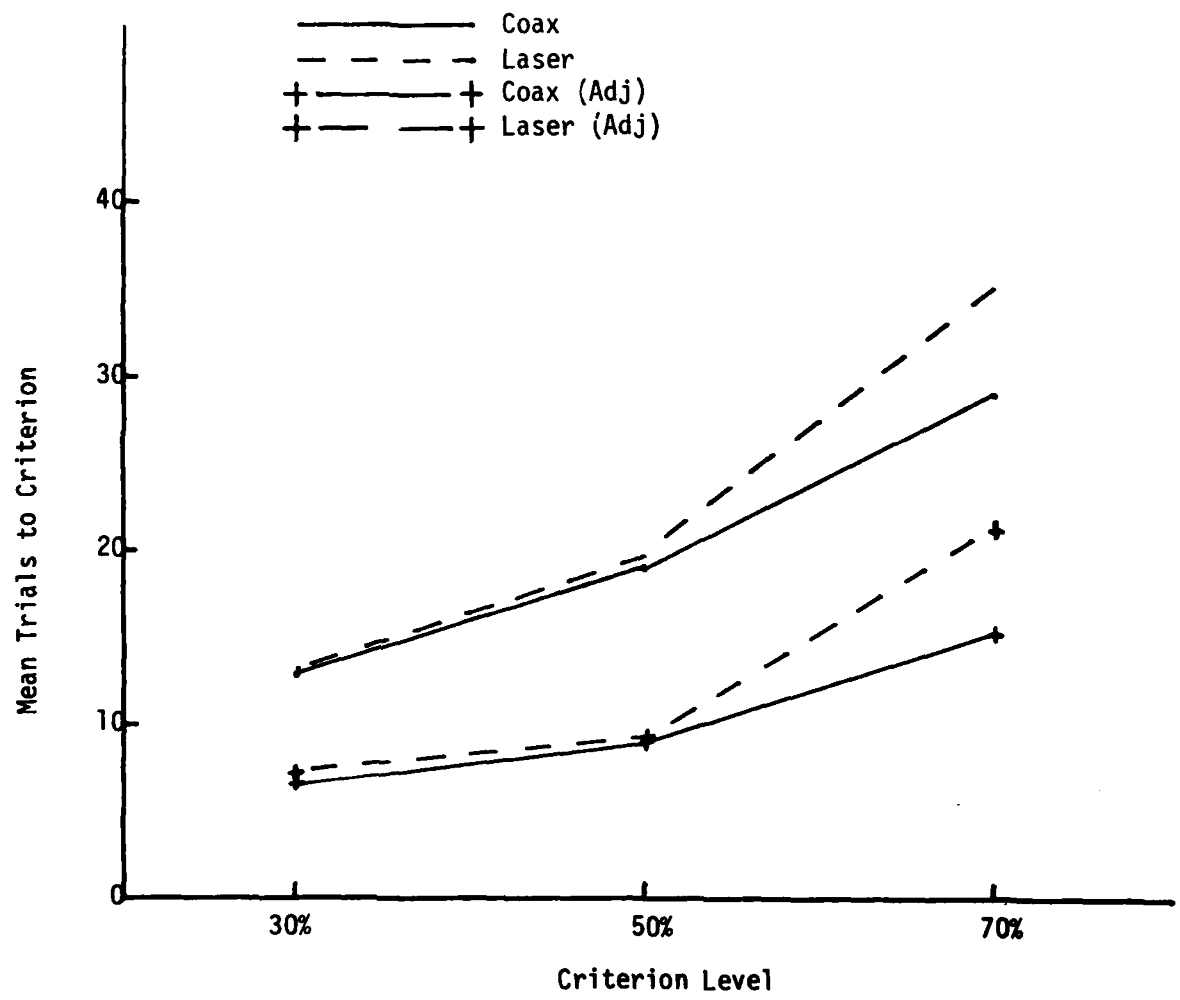

Figure 4. Mean trials needed to reach criterion levels during training.

TRANSFER OF TRACKING SKILL

The basic issue in this study was the ability of trainees, practiced to different levels of proficiency on the two training devices, to transfer their skills to the test situation. This situation required trainees to track and fire at a moving target, as accurately and as rapidly as possible.

Transfer of training was evaluated in terms of three kinds of measures. First, an accuracy score was calculated based upon the percent of hits obtained during each of four three-shot blocks. Transfer data were grouped arbitrarily in this manner to reveal changes in proficiency over time. Second, shots which missed the target were evaluated over the same four blocks. Misses were described as leading, lagging, short, or over. Finally, data were examined which represented the speed with which trainees were able to shoot after having received the command to do so.

Analysis of Hit Data. Percent hits was evaluated in a 2 x 3 x 4 analysis of variance in which the independent variables were the device, proficiency level, and block of trials. There were 22 trainees within each device/proficiency-level group. The analysis was based on an Arcsin square root transformation of the raw percentage data. This transformation was designed to reduce the correlation between means and variances often associated with raw proportional data.

The major finding from analysis of the accuracy data is shown in Figure 5. All groups show significant improvement in accuracy over the four blocks of trials [F (3,441) = 9.03, $p < .001$]. No significant differences were noted between devices or proficiency levels. Overall, trainees performed at a 48% hit rate initially and gradually improved to approximately 62% hits.

In addition to the full-scale analysis of variance, the transformed data were also subjected to a series of a priori planned comparisons based on t-tests of linear contrasts. In these comparisons each training group was compared to the control group at the first and last block of transfer trials. These comparisons revealed that upon initial transfer no trained group was significantly more accurate than the untrained control group. During the last block, however, the 70% coax group and the 70% laser group were both significantly more accurate than control trainees [t (441) = 1.91, $p < .05$, one-tailed] for both of the comparisons. Both of these groups scored 71% hits compared to the 53% hits obtained by the control group. It appears that the more highly trained groups do benefit from prior practice but that advantage only becomes evident after several trials in the transfer situation. In terms of the percentage of shots hitting the target during transfer it does not matter whether practice occurs on the laser or the coax device. No other comparisons among the data points of Figure 5 were statistically significant.

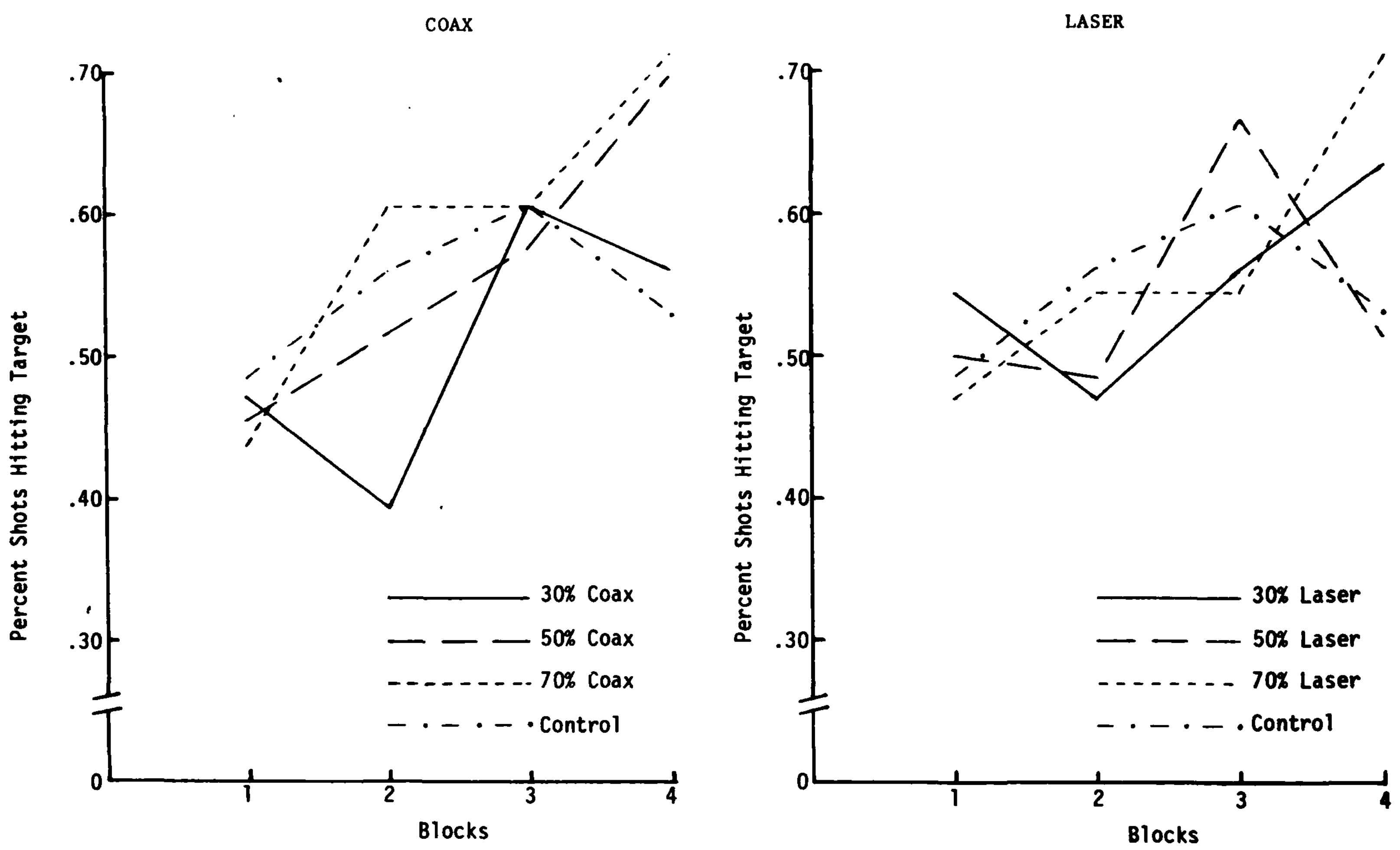

Figure 5. Percent hits during transfer as a function of trial block and device.

Analysis of Miss Data. Another way of assessing the effectiveness of prior training is to examine the kinds of misses which the various groups made. These data are shown in Figure 6 where percent hits as well as percent shots resulting in various kinds of misses are plotted as a function of blocks or trials. An analysis of variance of the Arcsin square root percent misses which were short of the target revealed no significant effects. As shown in Figure 6, only a small proportion of rounds was short of the target and this miss rate remained fairly constant during transfer. Gains in accuracy were not paralleled by associated decreases in percentages of short rounds.

Figure 6 shows that upon initial transfer the percentages of over rounds was nearly three times greater than short rounds. However, trainees improved during the course of transfer, reducing the percentage of over rounds. An analysis of variance revealed a significant reduction in this kind of miss [F (3,44) = 2.27, $p < .001$]. A priori planned comparisons detected further differences. By the fourth block of trials the 70% coax and laser groups had miss rates (17%) which were significantly lower [t (441) = 1.77, $p < .05$, one-tailed] than that of the control group (30%). The relative superiority of the trained group in committing fewer over misses is due in large part to the performance of the 70% groups.

Misses where rounds lagged the target were more common during initial transfer than misses resulting from too much lead. The percentage of lagging misses decreased over trial blocks. An analysis of variance revealed the block effect to be significant [F (3,441) = 3.27, $p < .02$]. There were no other significant effects on rounds which fell behind the target.

An analysis of variance of misses which were in front of the target was also conducted. A significant interaction was found between criterion level during training and trial block during transfer [F (6,378) = 3.08, $p < .006$]. The interaction implies, as shown in Figure 7, that the three criterion groups behaved differently over the course of transfer. Analyses of variance of simple effects were undertaken to investigate the interaction in more detail. Basically, such analyses permit permit one to examine differences among groups at each block of trials or, alternatively, differences in performance across blocks for each group.

Significant differences among proficiency levels occurred at the second block of transfer trials [F (2,504) = 3.89, $p < .05$]. Scheffe tests were conducted to get at the nature of the differences. During the second block of trials the group trained to the lowest criterion (30%) had a significantly greater percentage of leading errors than the most highly trained (70%) group [F (2,129) = 3.71, $p < .05$]. This relationship is shown in Figure 7.

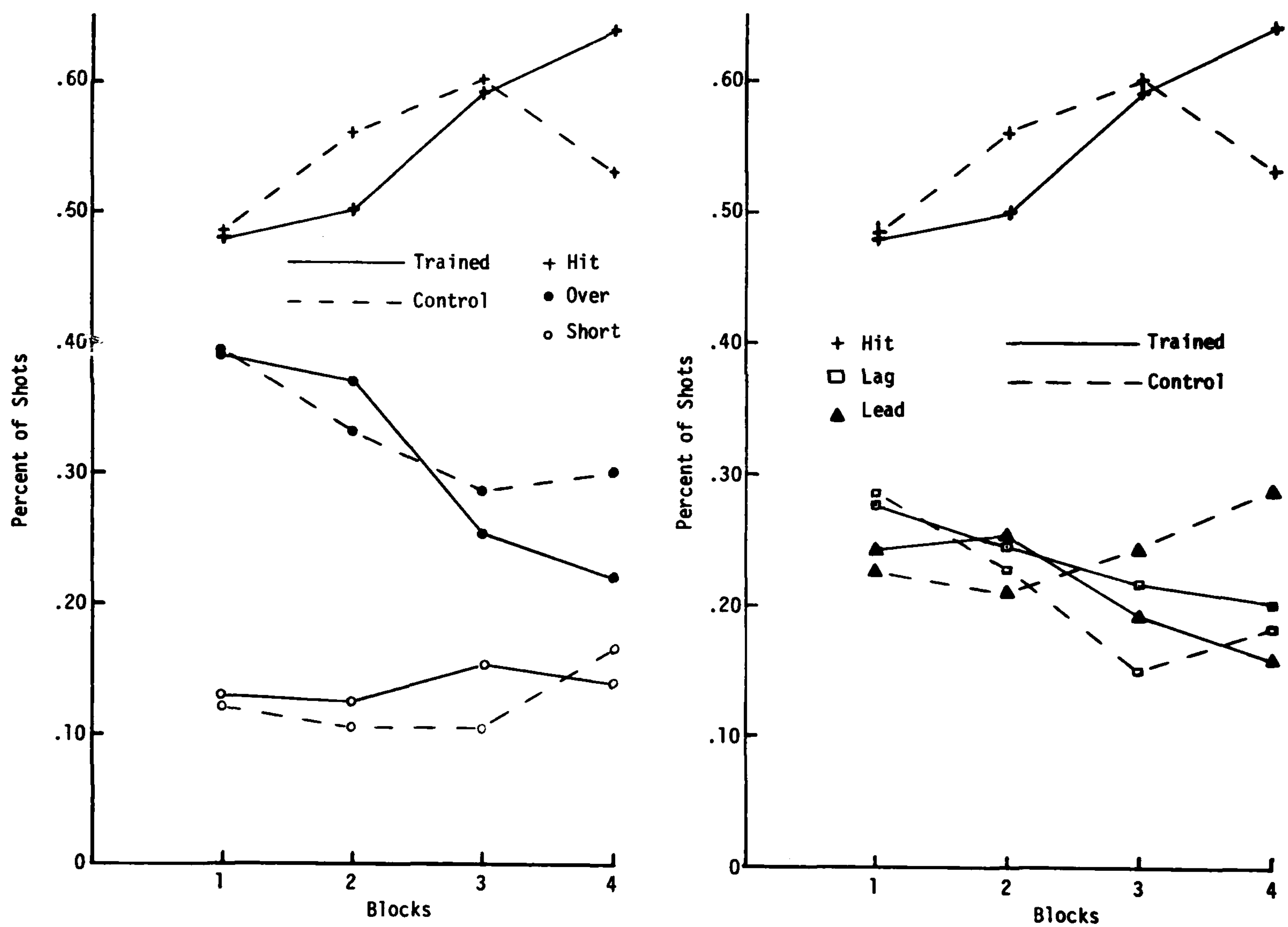

Figure 6. Percent of shots hitting or missing the target, during transfer.

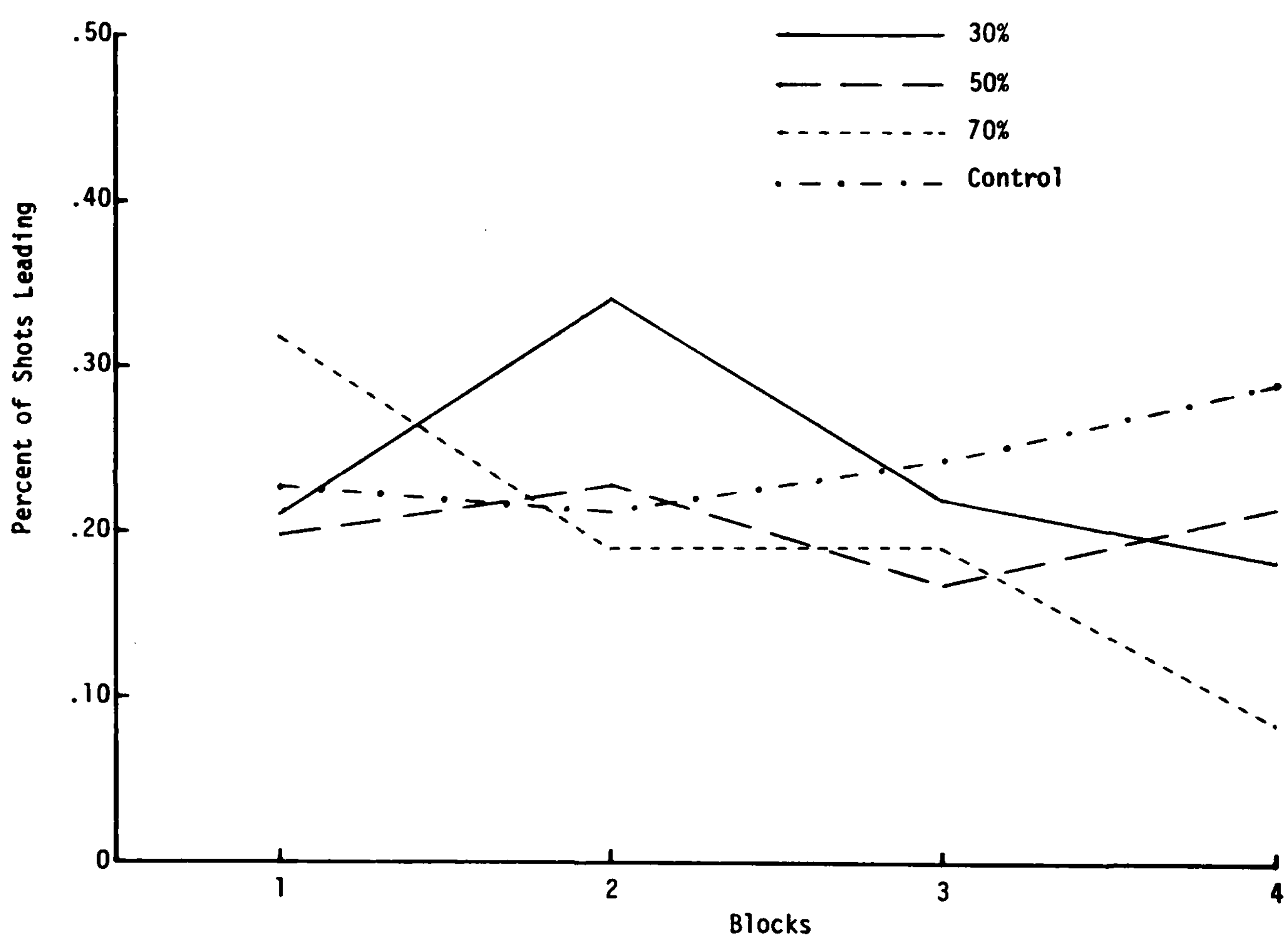

Figure 7. Percent of leading misses as a function of trial block and training criterion.

Another way of looking at these same data was to examine the changes in percent leading misses which occurred across the four blocks of transfer trials. The results indicated that trainees in the 30% and 70% groups had significantly different percentages of leading error as a function of transfer block. Trainees in the low proficiency training group decreased their leading errors significantly between the second and fourth blocks [F (3,378) = 4.76, $p < .05$]. However, their miss rate at the end of transfer was not different from their initial miss rate. On the other hand, trainees in the high proficiency training group decreased their leading errors significantly during the course of transfer [F (3,378) = 9.65, $p < .01$]. This improvement in performance can be seen in Figure 7.

Linear contrasts were carried out on the leading-miss data, comparing the training and control groups at the first and last blocks of trials. Upon initial transfer the coax and laser 70% groups both commit more leading errors than the control group although this difference was not statistically significant by conventional standards. By the fourth block, both 70% groups were significantly superior to the control group [F (1,441) = 5.97, $p < .05$].

Finally, in addition to characterizing each type of miss as a percentage of the shots fired, each type was also examined as a percentage of the shots which <u>missed</u> the target. These data are presented in Table 1 for various trainee groups at the first and last (fourth) block of transfer trials. The 30% and 50% groups have been pooled within each device, and hit data have been included for comparison.

As shown in Table 1 all groups initially were more likely to shoot over the target than short of it when failing to secure a hit. By the fourth block, this tendency became less pronounced within each group. The 30/50% laser group and both 70% groups reached the point where they were only slightly more likely to be over than short (.55 and .58, respectively). Leading and lagging misses distributed themselves rather differently. Initially, all groups tended to commit lagging misses with the exception of the two most highly trained groups. Both 70% groups showed a tendency to commit more leading than lagging misses. By the end of transfer the picture had essentially reversed itself. While the other three groups tended to lead or lag in equal proportion, the 70% groups clearly lagged the target when they missed. These data suggested that decreasing miss rates were accompanied by a redistribution of misses which varied across groups. In other words, the different groups appeared to be increasing their accuracy by focusing on the reduction of different kinds of misses.

In summary, the groups trained to the 70% proficiency level displayed positive transfer during later stages of the transfer exercise. Their superior accuracy was achieved by reducing the number of rounds which either went over or led the target. The important determinant in transfer appeared to be the amount of training received rather than the nature of the device on which practice was given.

TABLE 1

Redistribution of Miss Pattern as a Function of Blocks During Transfer

	Percent Hits		Percent Misses Over*		Percent Misses Leading	
GROUPS	Block 1	Block 4	Block 1	Block 4	Block 1	Block 4
Control	.48	.53	.76	.64	.44	.61
Coax (30/50%)	.46	.63	.78	.71	.39	.51
Laser (30/50%)	.52	.58	.70	.55	.41	.48
Coax (70%)	.44	.71	.73	.58	.57	.26
Laser (70%)	.47	.71	.83	.58	.60	.32

*Percentages reported for misses "over" based on analysis of misses "over" relative to misses "short." Percentages reported for misses "leading" based on analysis of misses "leading" relative to misses "lagging." For example, of the control group's misses in Block 1, 76% were "over," and the remainder (24%) were short. Similarly, of the control group's misses in Block 1, 44% were "leading" while the remainder (56%) were lagging. In Table 1, therefore, values greater than 50% indicate a preponderance of "over" or "leading" misses while values less than 50% represent the opposite kind of miss, "short" or "lagging," respectively.

Analysis of Speed Data. At either four or six points during transfer (depending on the tank commander), the time which trainees took to fire a round after receiving the command to fire was recorded. If trainees fired three rounds per target pass, four time scores were recorded. If two rounds were fired, six time scores were recorded. Time data of this type were available from all trainees for the first shot fired during transfer. Means for each group are shown in Table 2. An analysis of variance revealed no significant difference among groups. On the average, trainees took 15.5 seconds to get off their first round. This rather long time is attributed to the loader on the one hand, and on the other, to the gunner's desire to let the target assume a flank position before firing. This experience was the first experience of the loaders with live-fire conditions. Although the average time required to fire a round decreased slightly from the first to the second half of transfer, no differences were noted which could be ascribed to device or training criterion variables. This lack of improvement in response speed is not an unexpected result however, since in AIT during initial gunnery training spped is not emphasized. The subjects in the present experiment were therefore unprepared to deal with the novel dependent variable of response speed.

TABLE 2

Mean Time (Seconds) To Fire First Shot During Transfer

Device	Criterion Level		
	30	50	70
Coax	15.25	16.70	15.80
Laser	16.30	15.20	14.30
Control	14.90	-	-

DISCUSSION

ACQUISITION OF TRACKING SKILL

The intent in using three different proficiency criteria during training was to produce groups of trainees having had differing amounts of practice and presumably representing fairly disparate skill levels. The 30% group was to have received a small amount of skill training, similar to orientation or familiarization training. The 50% and 70% groups were designed to represent moderate and relatively high amounts of practice. As is apparent in the trials-to-criterion data (Figure 4)m, however, neither the 30% nor the 50% group received any substantial amount of training in terms of number of practice trials. In effect, the 30% group received the amount of practice intended (i.e., basic familiarization), while the 50% group reached criterion much more quickly than had been anticipated. The net result was that these two groups did not effectively represent different skill levels upon completion of training. Relative to these two low-level groups, the 70% group clearly had a more difficult time reaching criterion. Their relatively extended practice was presumed to have resulted in a meaningfully higher level of skill. Therefore, while three distinguishable groups were desired as a result of amount of training, only two groups emerged: a relatively high proficiency group (70%) and a relatively low proficiency group (30/50%). The emergence of only two groups, however, still enabled the adequate examination of the effects of amount of practice on transfer.

Another aspect of the acquisition portion of the study was the "type" or "quality" of training as represented by the comparison between the two training devices. There were no differences in trials to criterion between the coax and laser devices at any proficiency level. On the one hand, this result was gratifying, in that if the devices differed in amounts of practice required to reach a given proficiency level, a comparison of the devices themselves purely in terms of "quality" of training would have been impossible. This was a mixed blessing, however, since equating the devices in terms of amount of practice essentially eliminated one of the major parameters potentially contributing to their differential transfer effectiveness, namely the relative difficulty of the two devices.

TRANSFER OF TRAINING: METHODOLOGICAL ISSUES

One of the most interesting outcomes of the transfer portion of the study was the general absence of clear-cut differences between the trained and untrained students in terms of the percentage of shots hitting the target. On the surface, one might be tempted to conclude that training on the coax or laser was simply ineffective, at least in terms of the training criteria used in the present study. Looking more deeply into the matter, however, there appeared to be several factors which may have acted to reduce initial levels of performance and to retard rates of improvement.

First, the general absence of initial transfer effects appeared to be due to factors associated with trainees' baptism in firing of the main gun. For example, there was a strong feeling among tank commanders that a trainee's performance on his first few rounds was more a function of his expectations about muzzle-blast, noise, recoil, etc., than of his training in tracking. Due to these situational factors and to awareness of the potential dangers in either the gunner's or loaders' position, most trainees appeared to approach their initial firing with some degree of apprehension. In fact, preparation for these experiences may have been as important a determinant of initial transfer as any amount of training on the laser or coaxial devices per se.

Second, the relatively short transfer exercise may have prevented more long-range transfer effects from becoming evident. A twelve-round transfer exercise may simply have been too short a test of the trainees' tracking and firing skill. For example, if the effect of prior training was on acquisition of skill with the main gun, rather than on initial performance, such an effect might not have become manifest until some larger number of rounds was fired. In fact, by the last block of trials the 70% groups were clearly superior to the untrained control group; and were the trends shown in Figure 5, for instance, continued, one might conclude that these differences would have become even more pronounced.

Finally, whether early or late in transfer, other aspects of the test situation may have acted to obscure transfer effects. Two such features may have been the relatively short range and the relatively large targets which were used in this study. First, due to the shortness of the range and target obscuration caused by muzzle blast, trainees experienced difficulty in following their rounds to the target. Thus, for any given round, immediate visual feedback was often of poor quality. Second, since the target was quite large, the auxiliary "hit" or "miss" feedback which trainees received from the tank commander or spotter was not particularly informative in terms of refining their sight pictures. This problem may have been compounded to the extent that individual tank commanders provided different amounts and types of feedback information. For example, one tank commander may have told his trainee that a round was a "miss," while another might have described the same round as "leading" or "short," or a hit as on the "front" or "rear" of the target. (The counterbalancing procedures described earlier dealt with many of these variables by insuring that they applied equally to all groups.) Overall, these and other conditions in the transfer setting presumably combined to obscure potential transfer effects, whether these were expressed as level of initial performance or as acquisition of main-gun tracking skill during the test exercise. Given these circumstances, therefore, the obtained effects were all the more striking.

TRANSFER OF TRAINING: TRACKING AND LEADING

The effects of prior training on accuracy during transfer were primarily limited to two outcomes. The trained groups became more

accurate over the course of the transfer exercise, and by the end of the test period the highly trained groups were more accurate than the control trainees. To examine why improvements in accuracy did or did not occur, particular attention was paid to an analysis of the patterns of missed shots early and late in transfer. A consistent pattern emerged for over and short misses (see Figure 6 and Table 1). Initially, all trainees were consistently over the target (i.e., aimed too high) when they missed. Across blocks of trials, the proportion of short shots remained relatively constant, while the number of "overs" gradually diminished. This was accompanied in the trained groups by an improvement in performance. The pattern of lead and lag misses (Figures 6 and 7, Table 1), however, was not consistent over time and varied among groups. For misses which occurred during Block 1, the two 70% groups tended to lead the target (i.e., aim too far in front of it) while the other groups tended to fire behind the target. By the end of transfer these patterns had essentially reversed themselves.

In retrospect, there are at least two hypotheses which might serve as possible explanations of this behavior. The first, and relatively more straightforward one, is that the 70% groups may have been successfully trained on a lead which subsequently proved to be inappropriate in the transfer situation. For both devices, trainees were required during training to lead the target by some substantial amount (for the laser, the built-in lead was five mils; for the coax, the lead was between one and five mils, depending on the specific tank). Indeed, a five-mil lead would have been appropriate during transfer, for the range (750 meters) and ammunition (Heat TPT) used were targets traveling about 10 miles per hour. It is possible, however, and not unreasonable to believe, that during the transfer exercise targets were traveling somewhat slower, perhaps five miles per hour. Were this the case, a lead of 2.98 mils would be appropriate, and the five-mil lead learned by the 70% groups would result in an initial preponderance of leading errors (relative to lag), as was found. The 30/50% groups, not having learned to track or lead properly due to more limited practice, would initially lag the target by applying too little (if any) lead. The reversal in miss pattern which occurs later in transfer, therefore, may be the result of both groups attempting to compensate for their initial kind of miss. The 70% groups translate leading misses into proportionately more hits; when they do miss, they tend to lag. The 30/50% groups, however, apparently overcompensate and turn lag misses into lead misses, with less improvement in accuracy.

Instead of or in addition to this first hypothesis, one might speculate about a second explanation for the lead/lag reversal which was found. This deals with the method of applying lead independent of the amount of lead applied. Assume again that the 70% groups were in fact trained to lead the target during training by some substantial amount. During this training period, the targets for both devices were relatively smaller than the targets used in the transfer situation (the 6" x 8" coax targets projected to 8.75 feet at 750 meters; the 3.5" laser targets projected to 4 feet at 750 meters, both projections compared to the 16-foot targets actually used). Given these perceptual characteristics of the training and transfer situations, it could be hypothesized

that with extended practice trainees developed a method for applying the lead on their training device that was inappropriate for the transfer task. Perceptually, for both training devices the correct aiming point places the crosshairs somewhere considerably in front of the target; however, in the transfer situation a five-mil lead from the center of the target would place the crosshairs closer to the leading edge of the target itself. Suppose that during training, even though it is counter to Army doctrine, some trainees learn a shortcut method of applying lead which is simply to estimate the correct lead by judging the distance between the crosshairs and the leading edge of the target. During transfer, use of this same shortcut would result in leading misses since placing the crosshairs that same distance in front of the target would result in a greatly increased lead. Parenthetically, the failure of the 30% and 50% groups to exhibit a disproportionate number of leading misses during initial transfer might stem from the fact that training for these groups was too short for trainees to develop this inappropriate shortcut strategy. Further support for this hypothesis (and for the inappropriate lead hypothesis stated first) is the statistically insignificant but interesting finding that, with respect to the first block of trials, accuracy was inversely related to proficiency during training: the control group did best, the 30% groups did next best, the 50% groups next, and the 70% groups did worst. In a sense, this is an example of negative transfer: the more training, the poorer the performance upon initial transfer to the live-fire range.

Finally, some speculations can be offered as to why the 70% groups reached accuracy levels superior to the other groups by the end of transfer. The simplest explanation is that the highly trained groups were better able to use whatever feedback they received. In order to have reached a 70% proficiency criterion, a trainee must have learned how to adjust his fire on the basis of feedback. He would have learned the relationship between a control adjustment and the results of his next shot. Again, it could be hypothesized that the less-well-trained groups, especially the control group, never had the opportunity to learn these relationships. These trainees would have been at a disadvantage during transfer if, for example, they were told (or they observed) that their rounds were too far in front of the target. Should they make a small or a large adjustment? The data tend to indicate that the less-well-trained trainees fluctuated between leading too much and lagging too much, with no consistent pattern of error correction, and incidently, without any substantial improvement in accuracy. On the other hand, the 70% groups showed a consistent reduction in leading misses and a consequent increase in accuracy.

Thus, it appears that amount of training has both a positive and negative impact on transfer. It is positive in the sense that more highly-trained students can make better use of feedback and can eventually reach a higher performance level, and negative in that they may have learned the "wrong" leand and/or method of applying lead for the task at hand, and consequently, do poorly at first.

IMPLICATIONS AND CONCLUSIONS

An important point that should be considered before any of the implications discussed below are acted upon is the need for a clear specification of the Army's objectives in providing gunnery training to AIT or AOB students. On the one hand, for example, the objective within AIT may not be to provide gunnery skill training, per se, but merely to familiarize students with some of the principles of gunnery and provide them with some experience in live firing of the main gun. Another possible objective for AIT is to provide trainees with at least a fair degree of proficiency in main-gun firing and procedures. The implications should be considered in light of these different objectives.

One implication of the present study concerns the cost effectiveness of training students to a pre-set criterion on the training devices prior to main-gun firing. First, the problem of selecting an appropriate proficiency level is a difficult question (as illustrated in the present study). If the level chosen is relatively high, some trainees may not reach criterion within a reasonable amount of time. It may be costly to continue to provide training to a relatively few individuals who have difficulty in achieving the criterion. On the other hand, if the proficiency level is relatively low (in order to enable all trainees to reach the criterion), there is no assurance that adequate training would be provided.

If the objective of training is only to provide some familiarization, the best approach is probably to provide a fixed number of trials, provided that a reasonable number can be determined. The criterion approach is probably most useful in situations where it is important that trainees attain a high level of proficiency during training, such as in Unit Training.

A second implication of the present study is that the Army may want to consider supplementing the existing practice on tracking with practice in applying leads. Both the laser and the coax devices were utilized in such a fashion that little effort was required on the part of the trainee in determining leads to use with the targets (e.g., he always applied the same lead, if any). During transfer, the target was larger than during training, so that the application of the same lead resulted in either leading errors or hits that were considerably in front of the target center of vulnerability. This problem was especially noticeable for the most highly trained groups. Consequently, the Army might want to investigate the feasibility of configuring these devices so as to provide training in applying appropriate leads to targets of different <u>apparent</u> sizes, moving at different speeds, etc. For this purpose the coax device may be superior to the laser, since the laser has a built-in lag.

Regarding the issue of the best way to sequence live firing, it is probably best to distribute shots across time. That is, there appears to be a certain amount of apprehension associated with the first few rounds that a trainee fires due to inexperience with the physical sensations of being inside the tank when the main gun is

fired. When trainees in the present experiment were allowed to fire six shots, get out of the tank, and come back at a later time to fire their other rounds, the apprehension was apparently reduced over the no-firing interval. Particularly with the 30% and 50% proficiency groups, there was a marked improvement after the first block of six shots. The implication may be that trainees should be given one or two "warm-up" rounds before they are required to fire for effect.

As far as determining which device is "better" for providing gunnery training, the present study suggests that they are equally effective in preparing trainees for transfer to the main gun. There were no differences in main gun accuracy as a function of which device trainees were trained on. Therefore, the Army would need to consider other factors about the two devices in order to make a decision as to which to use. These factors might include such things as cost, safety, equipment reliability, convenience, lead/lag flexibility, and the time required to provide a given amount of training.

SUMMARY

This report describes an experiment which is part of a larger effort with the objective of developing and evaluating a model which can be used to predict the effectiveness of training devices. The experiment reported here compares the effectiveness of different amounts of training on the 3A102B laser device and the M73 coaxial machine gun fired in the single-shot mode for preparing Advanced Individual Training (AIT) personnel to track with and fire the main gun of the M60A1 tank.

Three groups of 22 trainees were trained on each device until they achieved a proficiency criterion of 30%, 50%, or 70% hits. A seventh group of 22 trainees received no training and served as the baseline against which to evaluate the other groups. Following training all groups were transferred to a live-fire range where each trainee fired 12 main-gun rounds at a moving tank silhouette target. Time and accuracy data were recorded as were various kinds of miss data.

Results from the transfer phase indicated that:

1. Trainee accuracy improved over the transfer session. Although initial accuracy was at a comparable level for all groups, by the end of transfer the two most highly trained groups were significantly more accurate than the untrained control group.

2. The pattern of leading and lagging misses differed among groups and changed during transfer. Highly trained students initially applied too much lead while less well-trained students tended to lag the target. By the end of transfer these patterns were reversed.

3. Performance during transfer was unaffected by the type of device on which training occurred. The reported effects were related to amount rather than kind of training.

Conditions surrounding the training and test situations may have operated to suppress transfer effects. In particular, trainees may not have learned to apply lead appropriately. Implications from these disucssions include:

1. The need to specify the objective of gunnery training;

2. the provision for a fixed number of trials rather than a proficiency criterion when the objective is to familiarize trainees; and

3. the value of providing trainees with warm-up rounds during a live-fire exercise.

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APPENDIXES

APPENDIX A TRAINING SCORE SHEET

Trainee ____________________ Instructor ________________

Date __________ Time ___________ Social Security # ___________

Device _______________ Score _______________

First Shot Target/Error	Trial Number	Hit	Miss	Elapsed Time
2000	1	:		
1800	2	:		
1400	3	:		
1000	4	:		
1400	5	:		
1800	6	:		
2000	7	:		
1000	8	:		
1000	9	:		
2000	10	:		
1800	11	:		
1400	12	:		
1000	13	:		
1400	14	:		
1800	15	:		
2000	16	:		
2000	17	:		
1800	18	:		
1400	19	:		
1000	20	:		
1400	21	:		
1800	22	:		
2000	23	:		
1000	24	:		
1000	25	:		
2000	26	:		
1800	27	:		
1400	28	:		
1000	29	:		
1400	30	:		
1800	31	:		
2000	32	:		
2000	33	:		
1800	34	:		
1400	35	:		
1000	36	:		
1400	37	:		
1800	38	:		
2000	39	:		
1000	40	:		

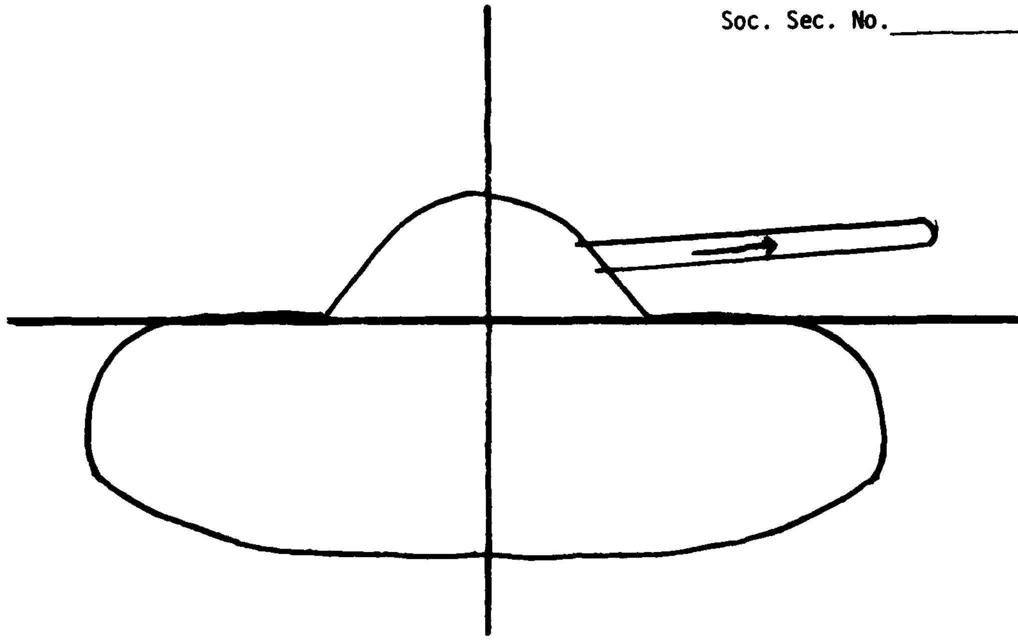
APPENDIX B

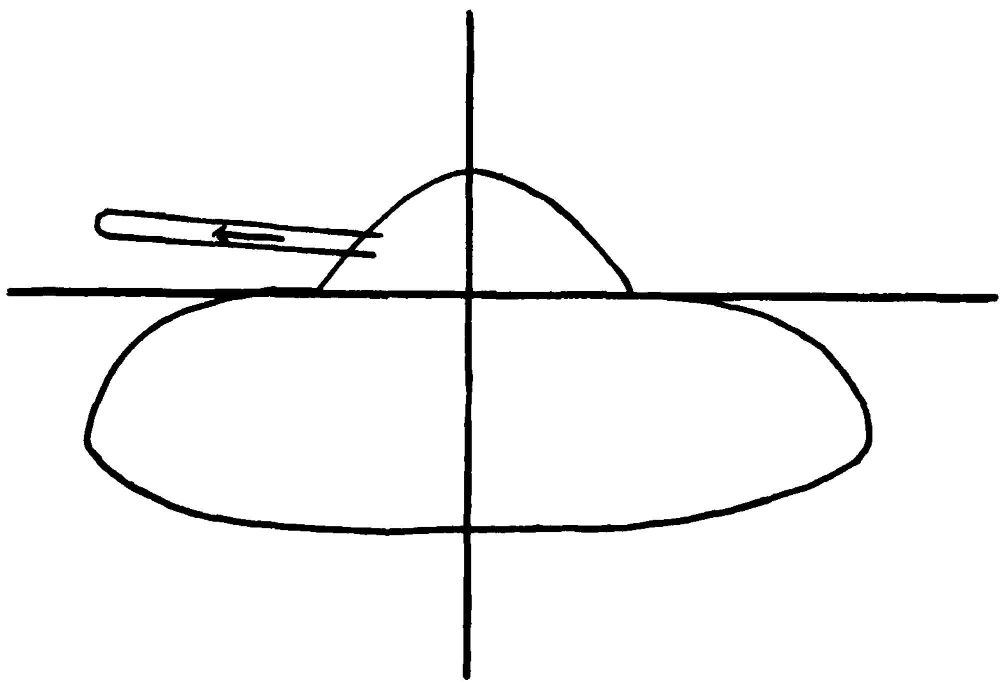
TRANSFER SCORE SHEET

Name________________________

Rank________________________

Soc. Sec. No.________________





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